METHOD AND APPARATUS FOR SPLICING WEBS

Field of the Invention

The present invention relates to the field of web splicing, and more particularly, to the field of methods and equipment for joining a second web to a first web, e.g., the splicing together of respective webs in sequence from a succession of web rolls.

Background of the Invention

The process of splicing a web (or "sheet") of material to another web of material is a common operation in a number of industries. Web splicing has been carried out in a wide variety of methods using a wide variety of devices.

In many industries, it is necessary to splice an end of one web and a beginning of another web together in order to maintain a single unbroken web. This splicing operation is often necessary for efficient operations downstream of the splicing equipment, e.g., where a downstream operation is fed with a steady and uninterrupted stream of web material. To maximize the efficiency of downstream operations, it is desirable to feed the web in a fast and steady manner without stopping or considerably changing the web speed.

In order that it not be necessary to shut down machinery used for continuously processing web material, it is advantageous to be able to splice a new roll of web material onto the moving web of the expiring roll being processed. With slow moving webs, this can be accomplished by a skilled operator manually without the need for sophisticated mechanical and electronic devices for monitoring movement of the web. Such manual splicing can be accomplished while leaving a relatively long tail on the expiring web since the web is moving so slowly that after the splice is made, the operator can then sever the trailing edge from the moving web to leave only a short overlap which has a relatively small chance of interfering with the subsequent processing equipment.

As the speed of processing increases, it becomes increasingly difficult for an operator to splice the new roll of web material manually onto the moving web, and either mechanical means must be used to accomplish this, or the machinery must be stopped or substantially slowed down while the splice is manually accomplished.

In an effort to provide increased efficiency, conventional web splicing systems employ

a variety of methods and assemblies to keep the web speed fed to downstream systems as fast and as continuous as possible. For example, as web material from an almost-expended roll (the "running roll") is fed at normal operating speed, certain systems will gradually bring a fresh roll of material (the "ready roll") up to the same speed, at which time the two webs are brought together and spliced.

In a representative speed match splicer, the actual splice is effected by pressing the running web momentarily against the surface of the ready roll at the adhesive area thereon after the running web and the ready web roll surface have been speed matched. The two webs become pasted together or spliced as soon as the splicing tape or adhesive area is rotated into engagement with the running web. Thereafter, a web cutter is actuated to sever the running web just behind the splice, thereby separating the running web from its nearly empty roll core, leaving the ready roll to supply the continuing needs of the web consuming machine.

Other conventional web splicing systems have focused on bringing the web from the ready roll up to speed very quickly. Such systems bring the ready roll web up to speed quickly in an attempt to reduce material waste.

As yet another example of how conventional web splicing systems attempt to feed downstream operations with a fast and continuous stream of web material through web splicing operations, certain systems use a bank of festoons or idler rolls immediately downstream of the splicer system. The festoon or idler rolls in such systems are adjusted to accommodate a significant amount of web material during normal web operations. When a web splicing operation is performed, the festoons or idler rolls move to release the web material wound therein. This process permits the web speed at the splice position (upstream of the festoons or idler rolls) to be temporarily reduced or stopped while the speed of the web material downstream of the festoons or idler rolls (i.e., for downstream machinery), is kept constant or only slightly reduced. When the splicing operation is complete, the web material passing the splicing area is brought back up to the speed of the web downstream of the festoons or idler rolls. A drawback of such web splicing systems is the need for one or more banks of festoons or idler rolls and control elements and assemblies required for their operation. These components increase cost, maintenance, and floorspace requirements. Furthermore, it is often of critical importance that a constant tension be maintained on the web throughout each operation performed upon the web. If constant tension is not

maintained, web wrinkling and (in severe cases) web rupture can occur. Each festoon roll or idler roll added to a system creates the possibility for web wrinkling and tensioning problems. Systems which attempt to address these problems by employing driven rolls in the bank of idler or festoon rolls inevitably introduce more expense, complexity, and maintenance costs into the system.

There is an ongoing need for methods and apparatus which are capable of splicing webs with improved reliability and repeatability. Furthermore, there is an ongoing need for methods and apparatus for splicing webs at higher line speed and/or with rolls of smaller diameter, while achieving adequate or improved reliability. These objects are achieved by the methods and apparatus according to the present invention, as described below.

Brief Summary of the Invention

According to the present invention, there is provided a web splicer, comprising:

a first roll supporter for supporting a first core having a first roll positioned thereon, the first roll comprising a first web wound around the first core;

a second roll supporter for supporting a second core having a second roll positioned thereon, the second roll comprising a second web wound around the second core;

a paster roll which is rotatable about a paster roll axis, the paster roll being movably mounted on a carriage;

a carriage driving device which causes the carriage to move from a first carriage position to a second carriage position after an engage signal is fed to the carriage driving device, whereby the paster roll abuts the second roll when the carriage is in the second carriage position; and

a pressing device which selectively causes force to be applied to the paster roll relative to the carriage.

In a preferred mode of operation of the web splicer according to the present invention, a first core having a first roll positioned thereon is supported by the first roll supporter and is being unwound at a substantially constant rate. A second core having a second roll positioned thereon is mounted on the second roll supporter and is brought up to a speed of rotation at which the outermost portion of the second web is moving at substantially the speed that the first web is moving. When splicing the second web to the first web, the carriage

driving device moves the carriage from the first carriage position to the second carriage position, preferably very rapidly, such that the paster roll abuts the second roll, with the first web positioned between the paster roll and the second roll. As a result, the first web comes into contact with the second web, which preferably has at least one splice region (e.g., a transverse region with paste or double-sticky tape applied thereto). The pressing device applies force which presses the first web against the second roll, such that as the second roll continues rotating, the splice region comes into contact with the first roll, and the first web and the second web are thereby spliced along the splice region. In such a way, the magnitude of force which moves the carriage from the first carriage position to the second carriage position is independent of the magnitude of force which presses the first web against the second roll. As a result, the force to move the carriage can be made very large, in order to provide very rapid, precise and consistent movement of the carriage, while providing the flexibility to apply a pressing force of any desired magnitude (the pressing force is preferably large enough that the movement of the carriage does not at any time eliminate the pressing force, e.g., during and immediately after the carriage is moved from the first carriage position to the second carriage position.

In a preferred aspect of the present invention, the paster roll is rotatably mounted on a paster roll bracket, the paster roll bracket is pivotally mounted on the carriage, and the pressing device is connected at one location to the carriage and at another location to the paster roll bracket, whereby force exerted by the pressing device applies force to the paster roll relative to the carriage.

According to the present invention, there is further provided a method of splicing a second web to a first web, comprising:

unwinding a first web from a first roll;

rotating a second roll, the second roll comprising a second web wound around a second core, the second web having a splice region on an external portion of the second roll;

actuating a pressing device to cause force to be applied to a paster roll relative to a carriage, the paster roll being movably mounted on the carriage;

moving the carriage from a first carriage position to a second carriage position upon an engage signal, whereby a portion of the first web is sandwiched between the paster roll and the second roll at a contact location;

whereby force applied to the first web between the paster roll and the second roll is controlled by force applied by the pressing device; and

whereby when the splice region passes through the contact location, the second web becomes attached to the first web along the splice region.

In a preferred aspect, the present invention further comprises detecting occurrences of a splice region on the second roll passing a detection location or region, and feeding the engage signal to the carriage driving device at a time whereby the carriage driving device brings the paster roll into contact with the second roll at a contact location when the second roll is between one-quarter and three-quarters of a revolution from said contact location.

The web splicer of the present invention provides extremely rapid, precise and consistent movement of the carriage on which the paster roll is movably mounted, thereby providing more repeatable splices, and improving splicing reliability. The web splicer of the present invention further makes it possible to accomplish these advantages even with smaller diameter rolls.

The present invention thereby provides methods and apparatus which are capable of splicing webs with improved reliability and repeatability. Furthermore, the present invention provides methods and apparatus for splicing webs at higher line speed and/or with rolls of smaller diameter, while achieving adequate or improved reliability.

The invention may be more fully understood with reference to the accompanying drawings and the following detailed description of the invention.

Brief Description of the Drawing Figures:

Fig. 1 is a schematic side view of a first embodiment of the present invention, in which the carriage is in the first carriage position.

Fig. 2 is a schematic side view of the first embodiment of the present invention, in which the carriage is in the second carriage position.

Fig. 3 is a sectional rear view of a first portion of the first embodiment of the present invention.

Fig. 4 is a sectional top view of a second portion of the first embodiment of the present invention.

Fig. 5 is a schematic side view of a second embodiment of the present invention, in

which the carriage is in the first carriage position.

Fig. 6 is a schematic side view of the second embodiment of the present invention, in which the carriage is in the second carriage position.

Fig. 7 is a schematic rear view of a portion of the second embodiment of the present invention.

Fig. 8 is a schematic side view of a third embodiment of the present invention, in which the carriage is in the first carriage position.

Fig. 9 is a schematic side view of the third embodiment of the present invention, in which the carriage is in the second carriage position.

Fig. 10 is a schematic top view of a portion of the third embodiment of the present invention.

Detailed Description of the Invention

As mentioned above, the web splicer according to the present invention comprises a first roll supporter, a second roll supporter, a paster roll, a carriage, a carriage driving device and a pressing device.

The first roll supporter can be any structure which can rotatably support a first core having a first web wound therearound, a wide variety of such supporting structures being well known in the art. For example, a suitable roll supporter can be a pair of members each having a recess or an opening in which an end of the core is positioned, with bearings located between the respective ends of the core and the corresponding respective recesses or openings in the supporting structures.

Similarly, the second roll supporter can be any structure which can rotatably support a second core having a second web wound therearound, suitable structures including structures like those mentioned above in connection with the first roll supporter.

Preferably, the web splicer includes at least a second roll driver which, when actuated, causes the second roll to rotate, and which can be adjusted to cause the second roll to rotate at a desired rate of rotation.

Figs. 1-4 schematically illustrate a first preferred embodiment of a web splicer in accordance with the present invention. Figs. 5-7 schematically illustrate a second preferred embodiment of a web splicer in accordance with the present invention. Figs. 8-10

schematically illustrate a third preferred embodiment of a web splicer in accordance with the present invention. Referring to Figs. 1, 2, 5, 6, 8 and 9, in each of the first, second and third embodiments, the first roll (or "running roll") 10 constitutes a first web 11 wound about a first core 12. The first core 12 is supported on a first roll supporter 13.

The second roll (or "ready roll") 14 constitutes a second web wound about a second core 15. The second core 15 is supported on a second roll supporter 16. The second core 1 has a prepared splice 37 attached to its exterior.

In Figs. 1 and 2, Figs. 5 and 6, and Figs. 8 and 9, the first roll (or "running roll") 10 is nearly depleted, and the second roll (or "ready roll") 14 is ready to be spliced onto the first web 11. The splicing operation can instead be performed at times other than when the first roll 10 is nearly depleted, for example, the first roll 11 need not be nearly depleted. In general, so long as there is sufficient web material on both webs to complete the splicing operation, the splicing operation can generally be performed at any time.

The term "web" as used herein means any form of ribbon material of any width, including but not limited to paper materials, paperboard materials, film materials, foil materials, non-woven materials, composite materials or any combination of such materials, which is to be unwound from a roll.

The cores in accordance with the present invention can be any structure capable of supporting the web wound thereon. A variety of core structures are well known to those of skill in the art, any of which can be employed in accordance with the present invention.

The second core is driven by any kind of driver, a variety of which are well known to those of skill in the art. For example, Fig. 3 shows a belt-and-pulley driver which can be operated to drive the second core 15. The belt-and-pulley driver depicted in Fig. 3 includes a motor 17, a first pulley 18 mounted on the motor shaft, a belt 19 and a second pulley 20 engaged with the second core 15. While a belt-and-pulley driver is depicted in Fig. 3, any device for driving the second core 15 can be employed, a variety of which (e.g., a gear drive) are well known to those of skill in the art.

In addition, if desired, the first roll can also be driven by any suitable means, as described above in connection with the second roll. Alternatively, the first web can be drawn solely by the drawing tension exerted by a downstream operation.

The web splicer in accordance with the present invention preferably also has devices

for moving the respective first and second rolls. In a preferred aspect of the present invention, starting from the arrangement depicted in Figs. 1, 5 and 8, after the first and second webs are spliced to each other and the first web is cut, as described in more detail below, the first core and any part of the first web still wound on the first core are moved away (e.g., by moving the first roll supporter) and the second core and the second roll are moved to the location where the first core and the first roll are positioned in Figs. 1, 5 and 8 (i.e., such that the axis of the second core is positioned substantially where the axis of the first core is located in Figs. 1, 5 and 8), e.g., by moving the second roll supporter. Then a third core with a third roll positioned thereon is moved to the location where the second core and the second roll are positioned in Figs. 1, 5 and 8. As such, the second roll thus becomes the running roll and the third roll becomes the ready roll. If appropriate and desired, additional rolls can be supplied and spliced in sequence in the manner described above.

Devices for moving the respective rolls can be any device capable of moving the cores and rolls, a wide variety of which are well known in the art. For example, a number of turret assemblies for moving multiple cores and rolls relative to one another are well known in the art. Similarly, core shaft loading and withdrawing devices may be employed as needed, such devices being well known in the art.

The paster roll can be any structure capable of reliably guiding the path of a web, e.g., any structure commonly used as an idler roll. A variety of such roll structures are well known to those of skill in the art, any of which can be employed as the paster roll in accordance with the present invention.

As mentioned above, the paster roll is rotatably mounted on the carriage, and is movable relative to the carriage. Referring to Figs. 1, 2, 5, 6, 8 and 9, in each of the first, second and third embodiments, the paster roll 21 is rotatably mounted on a paster roll bracket 22, and the paster roll bracket 22 is pivotally mounted on the carriage 26. The embodiments shown in Figs. 1 and 2, Figs. 5 and 6 and Figs. 8 and 9 each also include an idler roll 39.

The carriage in accordance with the present invention can be any rigid structure on which at least the paster roll can be movably mounted, and which can be driven from the first carriage position to the second carriage position by the carriage driving device. Preferably, the carriage is mounted such that it can readily move from the first carriage position to the second carriage position with minimum friction. Preferably, bearings are provided between

the carriage and a frame on which the carriage is slidably mounted. Bearings 40 are schematically depicted in the each of the first, second and third embodiments shown in Figs. 1 and 2, Figs. 5 and 6, and Figs. 8 and 9, respectively.

The carriage driving device in accordance with the present invention can be any device capable of driving the carriage from the first carriage position to the second carriage position after an engage signal is fed to the carriage driving device. A wide variety of driving devices are well known to those of skill in the art, and any of such driving devices can be employed in the present invention.

Where a servo motor (or motor) is employed as the carriage driving device, such servo motor(s) can include any motor(s) which can provide the force needed to move the carriage from the first carriage position to the second carriage position in the desired relatively short time span.

Preferably, the carriage driving device is able also to readily move the carriage from the second carriage position back to the first carriage position after a disengage signal is fed to the carriage driving device, thereby moving the paster roll so that it no longer is abutting the second roll.

The web splicer depicted in Figs. 1-4 includes a servo motor 23, and a cam 24 mounted on a camshaft 25, the carriage 26 having a cam-contacting surface 27 which is in contact with the cam 24, the servo motor 23 being activated (upon receiving an engage signal) to drive the camshaft 25 and cam 24 180 degrees, from a first orientation (shown in Fig. 1) to a second orientation (shown in Fig. 2), thereby forcing the carriage 26 to move from the first carriage position (shown in Fig. 1) to the second carriage position (shown in Fig. 2), thereby moving the paster roll 21 from a first location (shown in Fig. 1) where it is not abutting the second roll 14 to a second location (shown in Fig. 2) where it abuts the second roll 14. Upon receiving a disengage signal (after the splice has been completed), the servo motor 23 is again activated to drive the camshaft 25 and cam 24 an additional 180 degrees, thereby moving them from the second orientation (shown in Fig. 2) back to the first orientation (shown in Fig. 1), thereby forcing the carriage 26 to move from the second carriage position (shown in Fig. 2) back to the first carriage position (shown in Fig. 1), thereby moving the paster roll 21 from the second location (shown in Fig. 2) where it is abutting the second roll 14 back to the first location (shown in Fig. 1) where it is not abutting the second roll 14.

The web splicer depicted in Figs. 5-7 includes a servo motor 123, and a cam 124 mounted on a camshaft 125, the carriage 26 having a cam-contacting surface 127 which is in contact with the cam 124, the servo motor 123 being activated (upon receiving an engage signal) to drive the camshaft 125 and cam 124 about 340 degrees (counter-clockwise in Fig. 5), from a first orientation (shown in Fig. 5) to a second orientation (shown in Fig. 6), thereby forcing the carriage 26 to move from the first carriage position (shown in Fig. 5) to the second carriage position (shown in Fig. 6), thereby moving the paster roll 21 from a first location (shown in Fig. 5) where it is not abutting the second roll 14 to a second location (shown in Fig. 6) where it abuts the second roll 14. Upon receiving a disengage signal (after the splice has been completed), the servo motor 123 is again activated to drive the camshaft 125 and cam 124 back about 340 degrees to its original position, i.e., from the second orientation (shown in Fig. 6) back to the first orientation (shown in Fig. 5), whereby a device (e.g., a spring, not shown) which exerts a force on the carriage in a direction which pushes the carriage 26 from the second carriage position back to the first carriage position, is able to push the carriage 26 back to the first carriage position (shown in Fig. 5), thereby moving the paster roll 21 from the second location (shown in Fig. 6) where it is abutting the second roll 14 back to the first location (shown in Fig. 5) where it is not abutting the second roll 14.

The web splicer depicted in Figs. 8-10 includes a servo motor 223, a gear 228 integrally connected to a gearshaft 229, the gearshaft 229 being driven via a gearbox 230 by the servo motor 223, the carriage 26 having a rack 231 having rack teeth 232 which engage teeth 233 of the gear 228, the servo motor 223 being activated (upon receiving an engage signal) to drive the gearshaft 229 and gear 228 so as to move the carriage 26 from the first carriage position (shown in Fig. 8) to the second carriage position (shown in Fig. 9), thereby moving the paster roll 21 from a first location (shown in Fig. 8) where it is not abutting the second roll 14 to a second location (shown in Fig. 9) where it abuts the second roll 14. Upon receiving a disengage signal (after the splice has been completed), the servo motor 223 is again activated to drive the gearshaft 229 and gear 228 in the opposite direction so as to move the carriage 26 from the second carriage position (shown in Fig. 9) back to the first carriage position (shown in Fig. 8), thereby moving the paster roll 21 from the second location (shown in Fig. 9) where it is abutting the second roll 14 back to the first location (shown in Fig. 8) where it is not abutting the second roll 14.

As mentioned above, the pressing device selectively causes force to be applied to the paster roll relative to the carriage, in order to apply a specific force between the paster roll.and the second roll. As such, the force applied between the paster roll and the second roll can be specifically selected, and the magnitude of that force is independent of the force used to move the paster roll from the first location to the second location.

Any pressing device which is capable of applying a force to the paster roll relative to the carriage can be employed, a wide variety of such devices being well known to those of skill in the art. For example, a preferred pressing device is a pneumatic cylinder device, such devices being well known in the art. Alternatively, for example, a hydraulic cylinder device could readily be employed.

In the first, second and third embodiments, shown in Figs. 1-4, Figs. 5-7 and Figs. 8-10, respectively, a cylinder device 34 is provided, the cylinder device 34 having a first connecting element 35 and a second connecting element 36. The first connecting element 35 is connected to the carriage 26, and the second connecting element 36 is connected to the paster roll bracket 22. As such, the cylinder device 34, when actuated, causes force to be applied to the paster roll 21 relative to the carriage 26. The force exerted by the cylinder device 34 between the paster roll 21 and the second roll 14 is adjustable by regulating the pressure within the cylinder, e.g., in the case of a pneumatic cylinder device, by regulating the air pressure within the cylinder device 34.

The web splicer according to the present invention preferably further comprises a web cutter for cutting the first web after splicing the first web to the second web. Any web cutter can be employed, and a variety of web cutters are well known to those skilled in the art. An example of a suitable web cutter is a web cut off knife which may be mounted within a shoe having a surface over which the web passes; when it is desired to cut the web, the cut off knife is extended above the surface of the shoe and into the path of the web, thereby severing the web. Fig. 1 depicts a shoe 41 within which a knife 42 is positioned.

In operation, the first web is unwound from the first roll (or "running roll"), the first web passing around and in contact with the paster roll and on to a downstream operation (e.g., a further processing operation or a winding operation) at a moving web speed. The degree of depletion of the first roll can be detected by any means, e.g., visually by a human operator or automatically by any of a variety of well known apparatuses for sensing when a

roll has reduced to a particular diameter, e.g., a photo detect eye. As the first roll is nearing the degree of depletion at which the roll change is to be effected, preferably, the second roll is positioned adjacent to the paster roll and is brought up to a circumferential speed which corresponds (at least substantially, e.g., to within 80-120 %) to the moving web speed. In order to cause the circumferential speed of the second roll to correspond, at least substantially, with the moving web speed, the moving web speed can be detected in any manner (suitable moving web speed detection techniques and apparatus being well known to those of skill in the art), and the circumferential speed of the second roll can be monitored and compared with the detected moving web speed. Based on the results of the comparison between the detected moving web speed and the detected circumferential speed of the second web, adjustments can be made to increase, decrease or maintain the circumferential speed of the second web. Techniques and apparatus for performing such operations are well known in the art. For example, the circumferential speed of the second roll can be automatically calculated by measuring or detecting the diameter of the second roll, and either setting the second roll driver to a specific RPM value or detecting the rate of rotation of the second roll and adjusting the power to the second driver to bring the rate of rotation of the second roll to a specific RPM value. Alternatively, as is well known in the art, sonics can be used to measure the velocity of the edge of the roll. Likewise, the speed of the moving web can be monitored accurately, e.g., by a tachometer or shaft encoder responding to the surface speed or angular velocity of a fixed diameter guide roller around which the moving web is trained. The surface speed of a web roll may also be determined by measuring the angular velocity of the roll using a shaft encoder operatively connected to an element supporting the web roll. Multiplying that angular velocity and the radius of the roll yields the surface speed of the roll.

When the first roll reaches the degree of depletion at which the roll change is to be effected, e.g., when the first roll is nearly depleted, an engage signal is sent to the carriage driving device, as a result of which the carriage driving device causes the carriage to move from the first carriage position to the second carriage position, whereby the paster roll is moved to a position where it abuts the second roll. Preferably, the movement of the carriage from the first carriage position to the second carriage position is extremely rapid, e.g., the time for such movement is on the order of from about 15 milliseconds to about 150 milliseconds. In general, for smaller ready roll diameters and more rapid web speeds, a

shorter time for movement of the carriage from the first carriage position to the second carriage position is desired. Greater horsepower (for the carriage driving device) is required, where the weight of the carriage is larger (e.g., where wider rolls are being spliced), to move the carriage from the first carriage position to the second carriage position.

A preferred further aspect of the present invention is a high degree of repeatability, i.e., small variance of the time for movement of the carriage from the first carriage position to the second carriage position. For example, it is preferred that the time for movement of the carriage from the first carriage position to the second carriage position on one occasion differs not more than 10%, preferably not more than 5%, more preferably not more than 2%, from the time for movement of the carriage from the first carriage position to the second carriage position on any other occasion.

Another preferred aspect of the present invention is the capability of automatic or simple manual adjustment of the web splicer of the present invention to vary the length of time for movement of the carriage from the first carriage position to the second carriage position. For example, the web splicer of the present invention can include a servo motor (functioning as the carriage driving device) which is adjustable to select different power settings so as to vary the time for movement of the carriage from the first carriage position to the second carriage position.

Preferably, by the time the carriage reaches the second carriage position, the pressing device has already been activated (e.g., in the case of a cylinder, the cylinder has been pressurized) to apply force to the paster roll relative to said carriage, such force pressing the paster roll, and the first web which is sandwiched between the paster roll and the second roll, against the second roll. More preferably, the pressing device is activated prior to the time that the engage signal is sent to the carriage driving device, so that when the carriage is moved to the second carriage position, the pressing device is exerting the desired force on the paster roll relative to the carriage (i.e., there is no delay while, e.g., the pressure within the cylinder builds up).

The second roll preferably has at least one prepared splice, i.e., a region on the second roll which creates the adhesion between the first web and the second web which holds the respective webs together and creates the splice. A variety of prepared splices are well known in the art. For example, a prepared splice can include a region of adhesive or a strip of

double-sticky tape.

Preferably, the carriage is moved into the second carriage position to bring the paster roll into contact with the second roll at a contact location when the prepared splice on the second roll is between 90 degrees and 270 degrees of rotation (preferably about 180 degrees) away from the contact location (i.e., such that the prepared splice rotates between one quarter and three quarters (preferably about one half) of a rotation of the second roll, after the paster roll comes into contact with the second roll, before the prepared splice passes through the nip between the paster roll and the second roll). Providing at least one quarter of a revolution after the paster roll comes into contact with the second roll and before the prepared splice passes through the nip helps to ensure that the paster roll is positively in contact with the second roll before the splice reaches the nip, and allows sufficient settle out time should there be any bounce of the paster roll off the second roll, thereby making the splice more reliable. Providing at least one quarter of a revolution after the previous occurrence of the splice passing through the nip before the paster roll comes into contact with the second roll helps to ensure that the splice does not prematurely engage the first web, and helps to ensure that any material which holds the leading edge of the second web on the second roll does not prematurely disengage and cause the second web to begin to unwind and fly away from the second roll before the second web is spliced to the first web. One example of a type of material which is well known to those of skill in the art for holding the leading edge of a web on its roll is a tear tab (or nose tab), which is essentially a length of tape which is stuck to both the leading edge of the web and the adjacent exposed section of the web which is just less than one web revolution from the leading edge. Typically, especially with wider rolls, a plurality of tear tabs are employed, the number of tear tabs depending on the width of the roll (more tear tabs for wider rolls), the circumferential speed of the roll (more tear tabs for higher speeds) and the diameter of the roll (more tear tabs for smaller diameters). Where one or more tear tabs are employed, after the second web is spliced to the first web, the tear tabs will pull away from the adjacent exposed section of the web as the second web is pulled away from the second roll along the path that the first web has been following.

In order to time the movement of the carriage relative to the location of the prepared splice (and thus also relative to the time before the prepared splice passes through the contact location), the web splicer preferably further includes a detector which detects occurrences of

the splice region on the second roll passing a detection location or region, as well as a timing device for creating a signal at a time where (1) the ratio of (i) the time since the last occurrence of the prepared splice passing through the nip and (ii) the time interval between occurrences of the prepared splice passing through the nip is equal to (2) one revolution minus the fraction of a revolution (e.g., one quarter or three quarters, as mentioned above) that is desired for the second roll to rotate after the paster roll comes into contact with the second roll and before the prepared splice passes through the nip. A variety of such detectors are well known to those of skill in the art. For example, the detector can be a photo detect eye (e.g., mounted on a frame of the web splicer, which can detect a mark placed on the second roll adjacent to the splice). A preferred example of a timing device is a device which includes a high-speed pulse generator and a high-speed pulse counter (e.g., mounted on the spindle). With such a timing device and detector, the web splicer can be operated whereby the pulse counter detects a pulse per revolution value, i.e., the number of pulses between occurrences of the splice region passing the detection location or region, and subsequently a signal is created when the number of pulses since the most recent occurrence of the splice region passing the detection location or region reaches a specific fraction of the pulse per revolution value. Preferably, the number of pulses at which the signal is sent is adjusted to account for the delay time between the creation of the engage signal and the time the carriage reaches the second carriage position (which delay time is, as mentioned above, preferably on the order of from about 15 milliseconds to about 150 milliseconds; and such delay time can readily be tested, taken to be a constant, and calibrated into the system). For example, where it is desired that the second roll rotate between one quarter of a revolution and three quarters of a revolution after the carriage reaches the second carriage position by the time the prepared splice reaches the nip between the second roll and the paster roll, the number of pulses is preferably between (1) one quarter of the pulse per revolution value plus the number of pulses corresponding to the delay time, and (2) three quarters of the pulse per revolution value plus the number of pulses corresponding to the delay time. Thus, before creating the engage signal, the web splicer preferably waits a number of pulses equal to the desired fraction of a complete revolution to be traveled times the number of pulses in a complete revolution, minus the number of pulses corresponding to the delay time, after the splice passes the detection location or region.

Preferably, the timing of movement of the carriage to the second carriage position is controlled with a programmable logic controller assigned to the carriage driving device. For example, the programmable logic controller preferably determines the precise timing for sending a signal to the carriage driving device based on (1) the time for the second roll to complete an entire revolution, (2) the fraction of a revolution to be traveled after the paster roll comes into contact with the second roll until the prepared splice passes through the nip, and (3) the delay time (i.e., as mentioned above, the time between the issuance of a signal and the time the carriage reaches the second carriage position).

In addition, the timing of actuating the web cutter to cut the first web is preferably timed such that the tail (i.e., the length of the first web which extends downstream of the splice between the first web and the second web) is relatively short and highly repeatable. It is preferred that the tail be less than one circumference of the first roll (as of the time of the splice). Preferably, however, in any event, the tail is not less than six inches in length (regardless of roll diameter). Preferably, the timing of actuation of the web cutter is controlled, relative to (1) the time that an engage signal is given to the carriage driving device, (2) the time between such engage signal and the splice region passing through the contact location, (3) the desired tail length, (4) the web speed of the first web, and (5) the cutter delay between the time that the web cutter receives a signal to actuate the web cutter and the time that the web cutter is in position to cut the web, with a programmable logic controller assigned to the web cutter, the web cutter having its own servo motor or pneumatic air device for actuating the web cutter upon receiving a signal from the programmable logic controller. For instance, as a representative example of a cutter delay, where the web cutter is a servo fired knife, the cutter delay can be, for example, on the order of about 15 msec (where the web cutter is a pneumatic knife, the cutter delay can be, for example, on the order of about 200 msec).

Fig. 1 schematically depicts a detector 43, a pulse generator 44, a pulse counter 45, a programmable logic controller 46 assigned to the carriage driving device, and a programmable logic controller 47 assigned to the web cutter.

After a desired length of time (preferably set or selected based on the desired tail length) has passed following the splice passing through the nip between the second roll and the paster roll, preferably a disengage signal is sent to the carriage driving device. Upon

receiving the disengage signal, the carriage driving device moves the carriage from the second carriage position back to the first carriage position, thereby moving the paster roll from the second location, where it is abutting the second roll back to the first location, where it is not abutting the second roll.

Any two or more structural parts of the web splicers described above can be integrated. Any structural part of the web splicers described above can be provided in two or more parts, which can be held together, if necessary or desired.